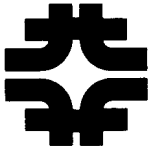


CDF Status and Upgrade Plans

Al Goshaw
Duke University and Fermilab

HEPAP Meeting
April 26, 2002

CDF Collaboration

North America

3 Natl. Labs
28 Universities

1 Universities

Europe

1 Research Lab
6 Universities

1 University

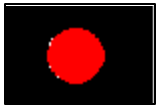
4 Universities

2 Research Labs

1 University

1 University

Asia



5 Universities
1 Research Lab

1 University

3 Universities

Totals

12 countries

58 institutions

581 physicists

Finland

Collaboration is growing by both number of people and institutions

Outline

- CDF detector status
- Recent data analysis
- Run 2b upgrade plans

CDF Detector Status

Brief Overview

CDF Detector Status

- A summary of the status and performance of each detector subsystem was presented to HEPAP at the October 2001 meeting.
  http://www-cdf.fnal.gov/spokes/CDF_Status_HEPAP.html

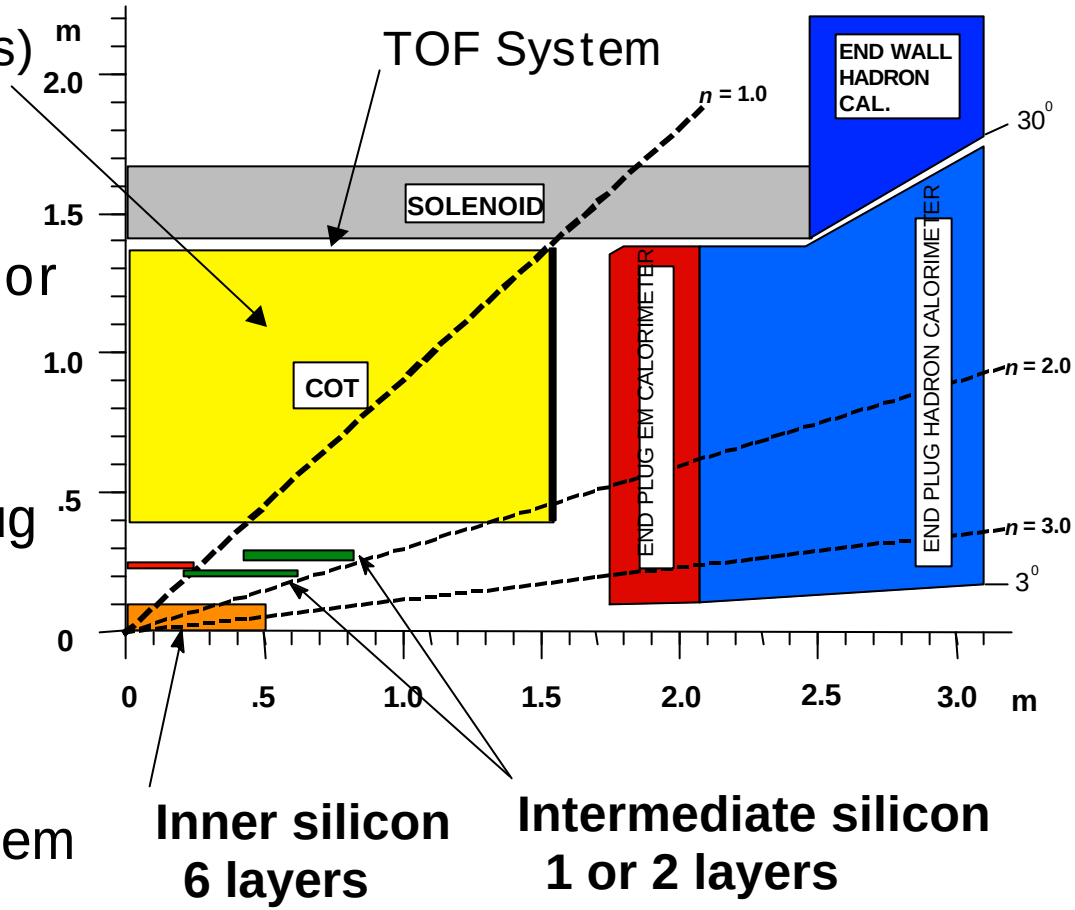
- Since then the detector has been operating with a rich collection of physics triggers, recording data that is being used for a variety of physics analyses.

- Today, briefly review the detector status, but concentrate mainly on what we have learned from preliminary studies of the data taken.

A Reminder:
CDF Run 2a Detector Upgrades

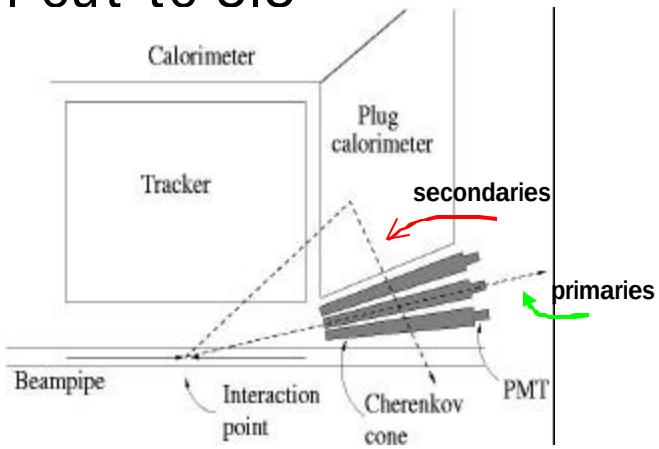
wire drift chamber (96 layers)

- A new 3d tracking system and vertex detector covering |?|out to 2.0.
- A new scintillating tile plug calorimeter covering |?| out to 3.6.
- A new time-of-flight system



A Reminder:
CDF Run 2a Detector Upgrades

- A new forward calorimeter covering |?| out to 5.5
- A new luminosity detector
- New front-end electronics (132 ns)
- New L1, L2, L3 trigger system (pipelined)
- New DAQ and offline data handling

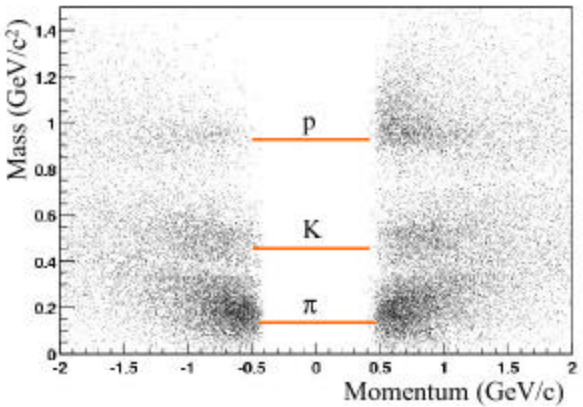


Detector Status

- Muon detectors: Operating with 92% of ?-? coverage
  - Small section of “miniskirt” being commissioned
  - High current draw in upper muon detectors
    - Working with Beams Division to reduce losses
    - Plan to install additional shielding at CDF in the fall

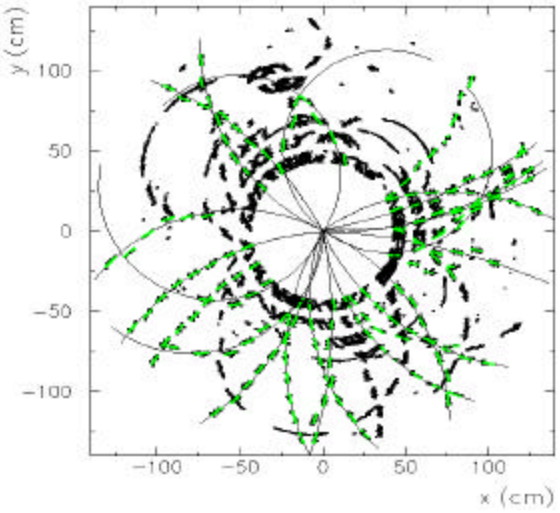
- Calorimeters: Operating with 100% of channels
  - Central and plug calorimeter fully integrated in trigger
  - New forward miniplug being commissioned

- Time of Flight:
  Operating with 100% of channels
  - Being used for offline particle ID

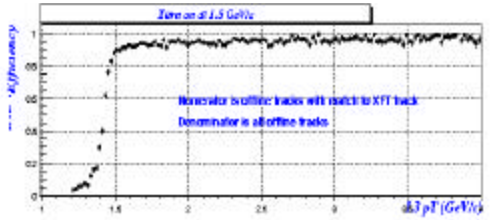


Detector Status

- Central Outer Tracker (COT):
  Operating with 99.8% of channels
  - Offline track reconstruction mature
  - Online L1 track trigger selects high Pt tracks (XFT)

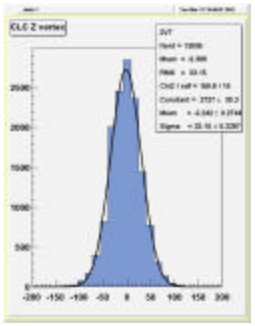


trigger efficiency



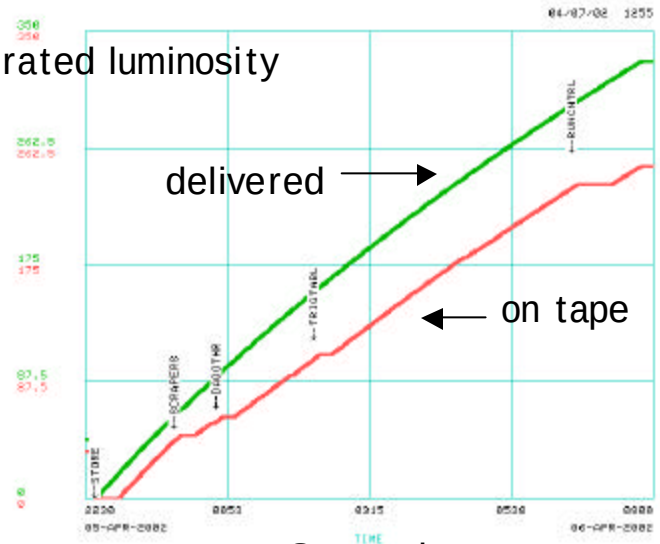
Track P_t

- Cherenkov Luminosity Counters (CLC):
  Operating with 100% of channels
  - Online and offline luminosity
  - Beam profile



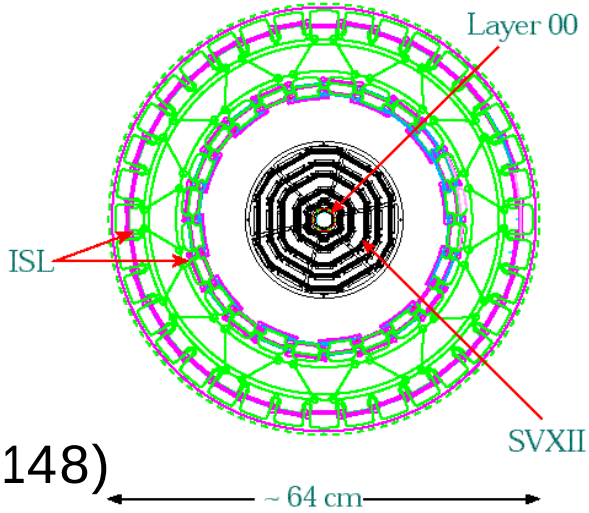
beam collision z

Integrated luminosity



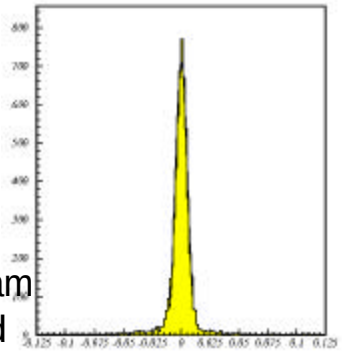
Store time

Silicon Detector Status



- Intermediate Silicon layer (ISL)
  - Operating with 60% of ladders powered (89/148)
  - Power off central barrel (|?| <1.0) until cooling lines cleared
- Silicon Vertex Detector (SVX)
  - Operating with 90% of ladders powered (324/360)
  - Online L2 trigger selects beauty and charm secondary vertices (SVT)

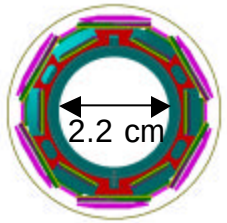
SVT impact parameter



?= 48 ?m including beam spot spread

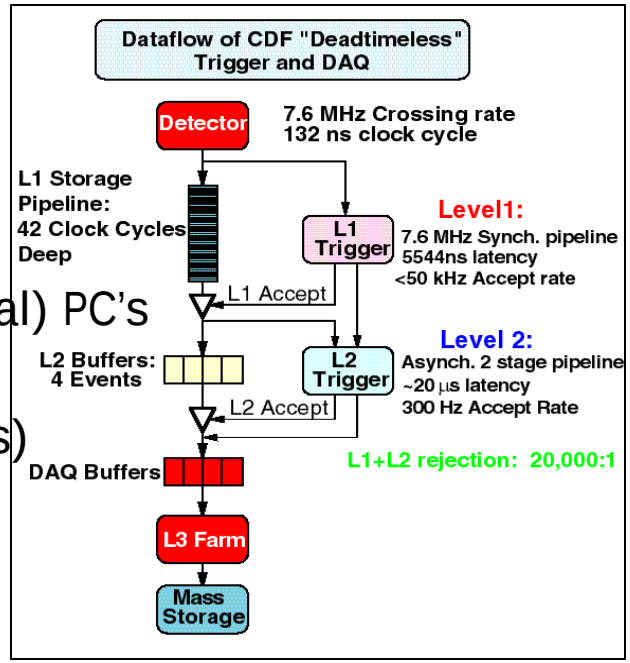
d_o (cm)

- Inner axial silicon layer on beam pipe (L00)
  - Operating with 95% of ladders powered (46/48)
  - Used offline for improving impact parameter resolution



Trigger and DAQ

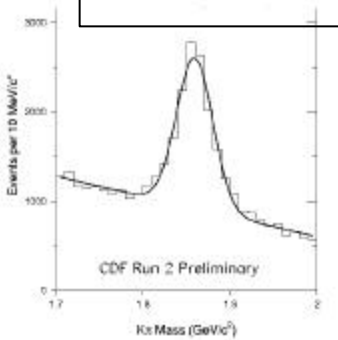
- L1, L2 and L3 triggers all operational
  - Running with 150 trigger paths
    - Jets, electrons, muons, photons, missing E_t
    - Multi-object triggers at L2
    - SVT triggers for beauty and charm at L2
    - L3 event reconstruction with farm of 144 (dual) PC's
  - At 1 x 10^{31} (and including many calibration triggers)
    - L1 accept rate 3.4 KHz
    - L2 accept rate 220 Hz
    - L3 accept rate 25 Hz
    - Dead time < 2 %
  - Have run at higher rates with special tests anticipating future luminosity
    - Current trigger table can accommodate luminosity to ~ 4 x 10^{31}
    - L2 accept rates and execution time the current limiting factor
    - Improvements will keep pace with Tevatron luminosity increases



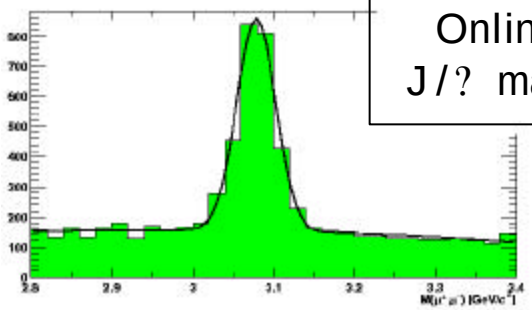
Trigger and DAQ

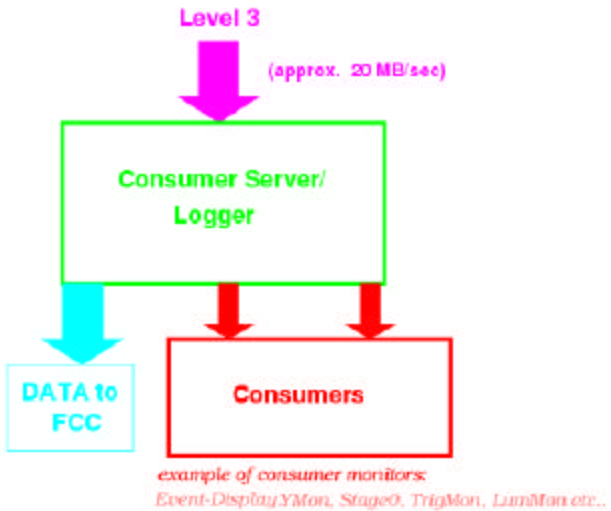
- DAQ system working as designed
  - Online database with running update of calibrations
  - Data logging rate at design of 20 MB/s
  - Good online data quality monitoring

Online
D -> K? mass



Online
J/? mass





- Data recorded for analysis since July 2001 = 22 pb^{-1}
  - Typical recent physics data collection efficiency ~ 80 %
  - Additional beam time used for trigger development
  - Down times logged and used to make improvements

Detector Status: Bottom Line

- The CDF detector is collecting physics quality data with triggers that feed all our major analysis topics.
- The detector, trigger and DAQ are ready for the higher luminosities expected from the Tevatron.
- The offline reconstruction (see results below) is in an advanced state for most physics analyses, and the offline farm operation is keeping pace with the data flow.
- Recent problems:
  - Removal of one COT wire plane for repairs (1/2500)
  - Concern about recent damage to silicon ladders
    - Accelerator interlocks being put in place
    - Studies of failure mode in progress

Recent Data Analysis

A sample:

W and Z bosons

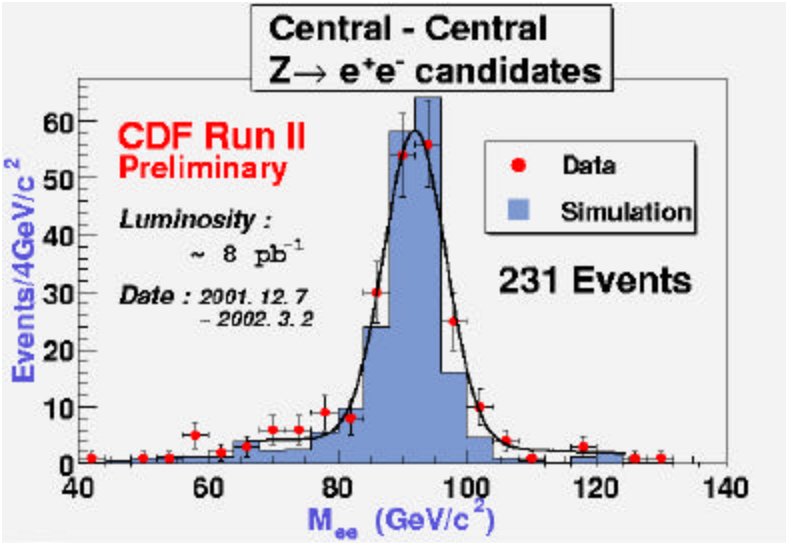
High Et jets

Beauty and Charm

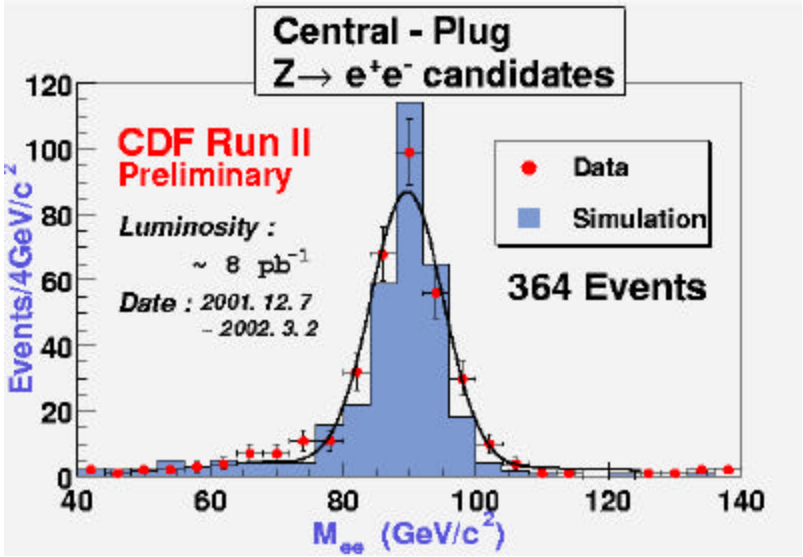
$Z \rightarrow e^+ e^-$

Z bosons provide an important monitor of detector/trigger performance and our understanding of the accuracy of simulations. Eventually Z -> b b will be used for measurement of di-jet mass resolution, critical for the Higgs search

Central Calorimeter

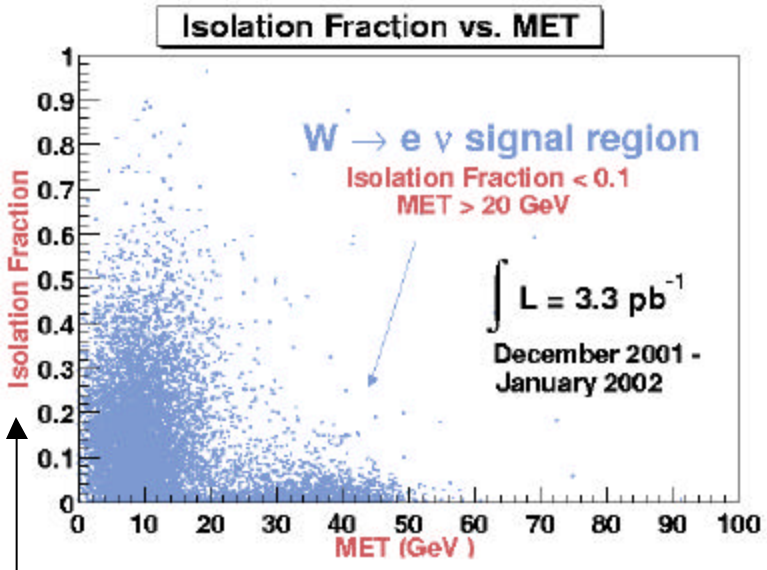


Central and Plug Calorimeter



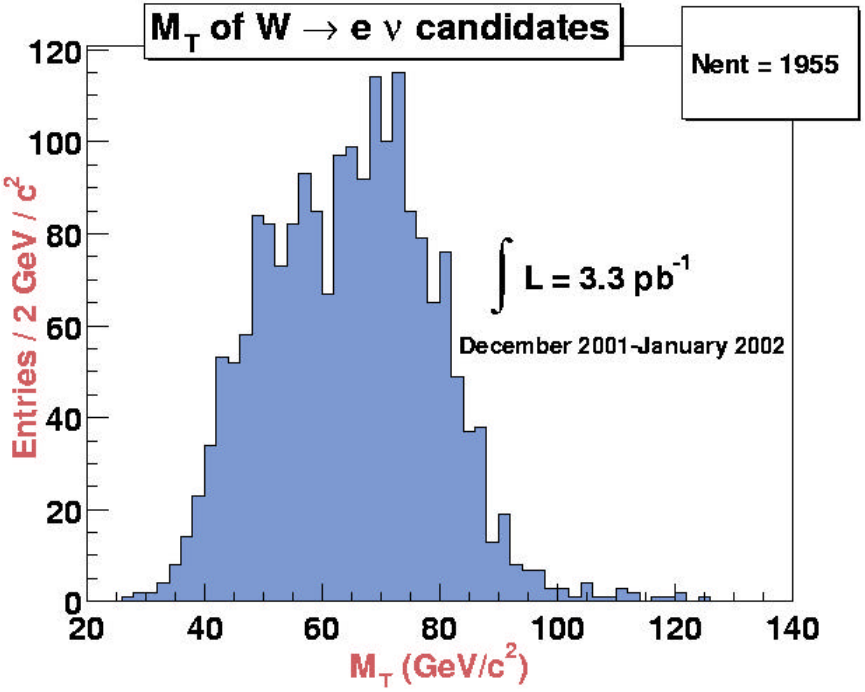
W → e ?

Precise measurement of the W mass and width are a central part of the Run 2a Physics program. Good W boson detection is obviously critical to top studies and future searches for the Higgs and other new physics.

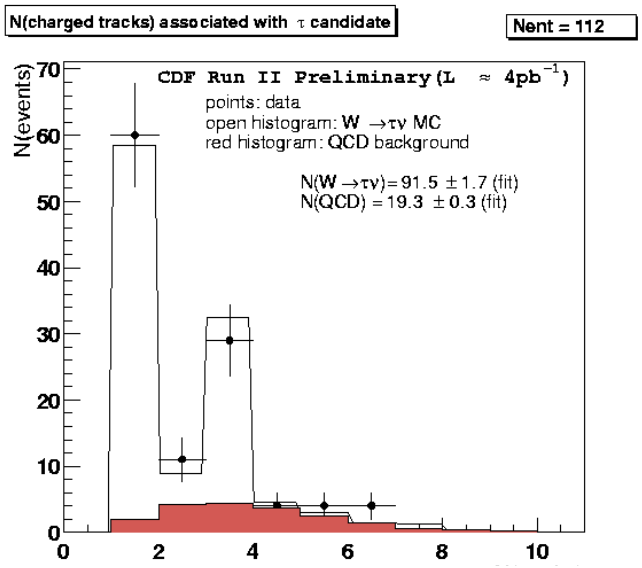


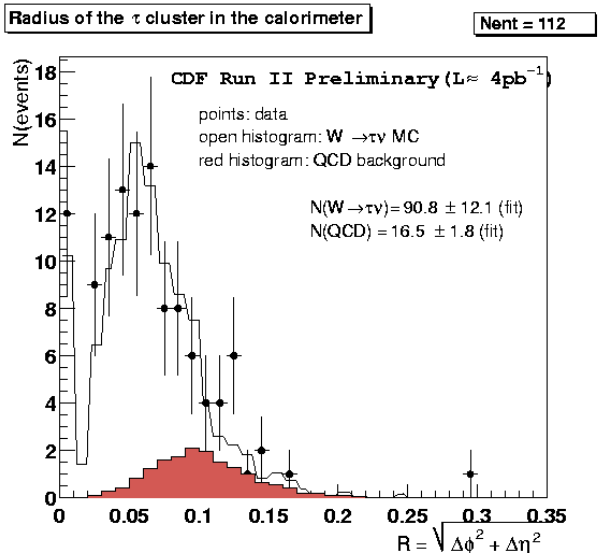
Fractional energy deposited in a 0.4 cone centered on the electron

Missing transverse energy

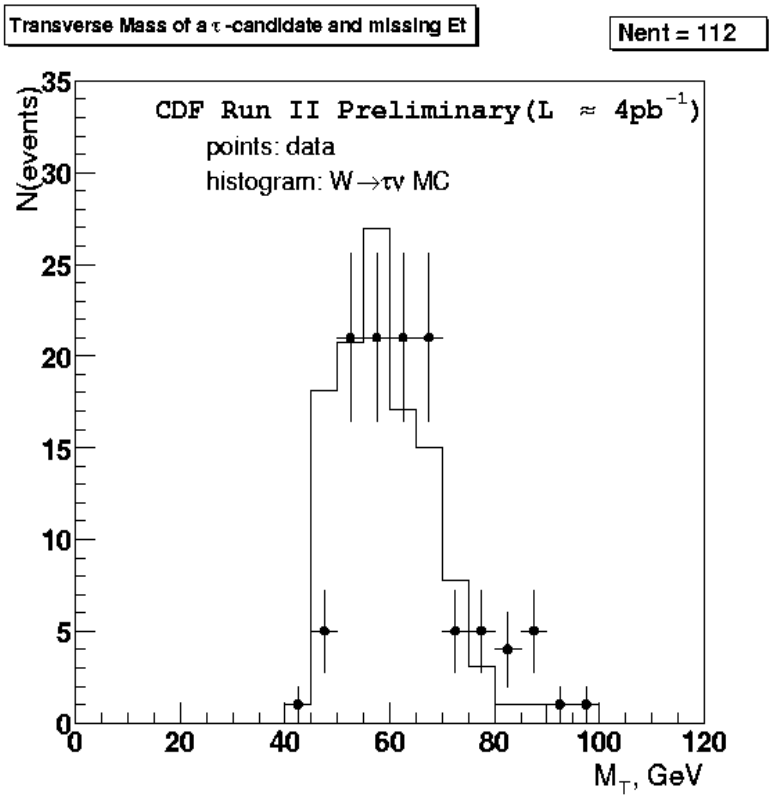


W → ? ?



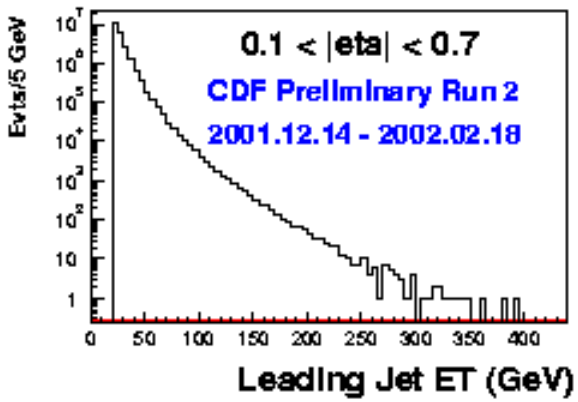


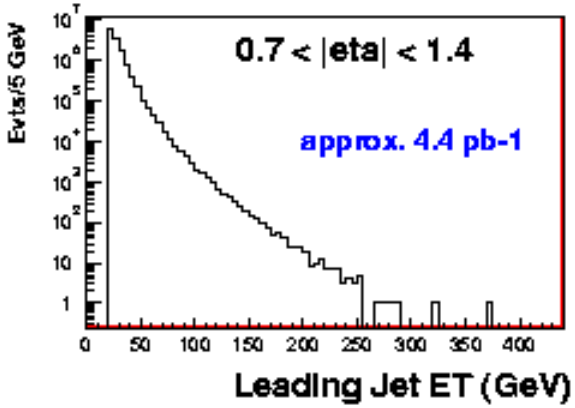
Tau lepton detection will provide additional tests of lepton universality and expand the range of SUSY searches



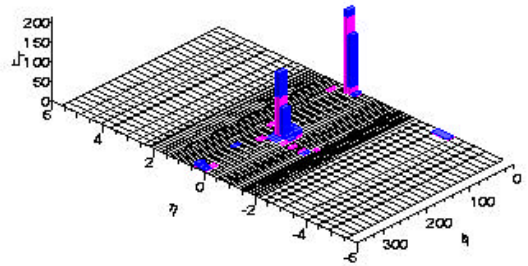
Towards high Et jet physics …

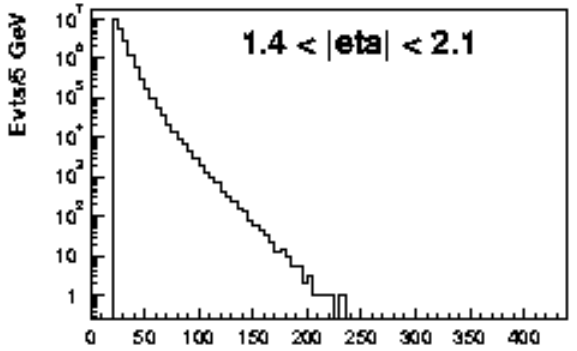
- Using the new plug calorimeter CDF can extend the the high Et jet probes to high |?|
- As shown below, there is a smooth transition between jet triggers with 20, 50, 70 and 100 GeV thresholds

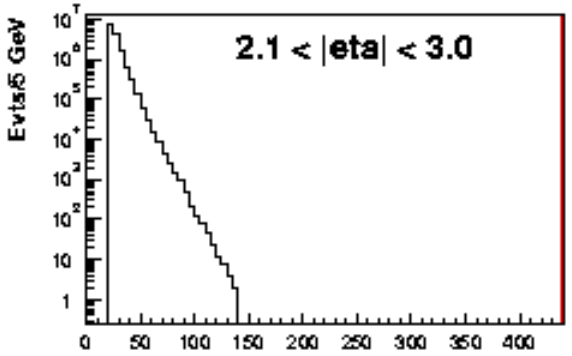




Highest Et
Di-jet
403, 322 GeV
(uncorrected)



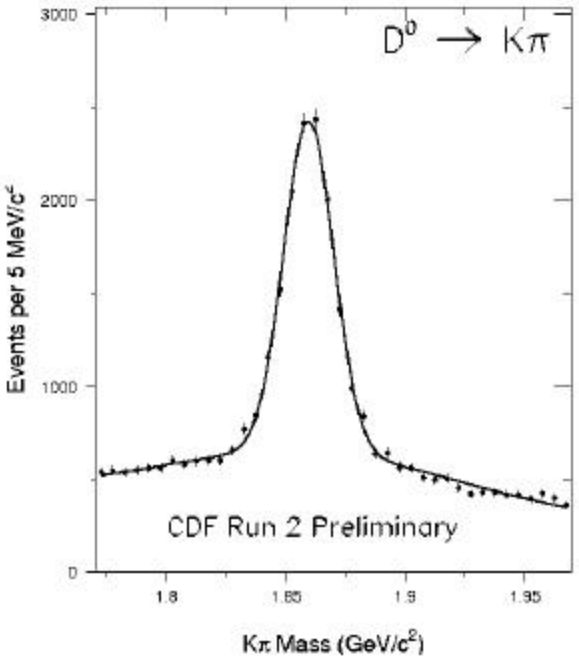


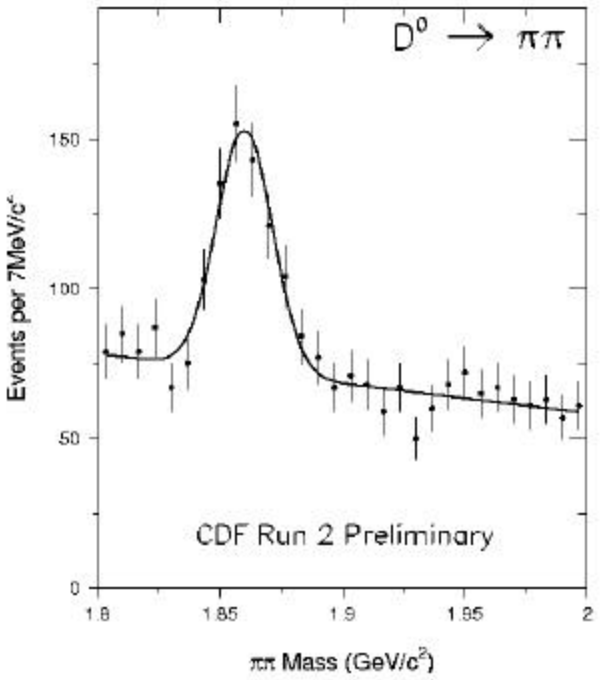


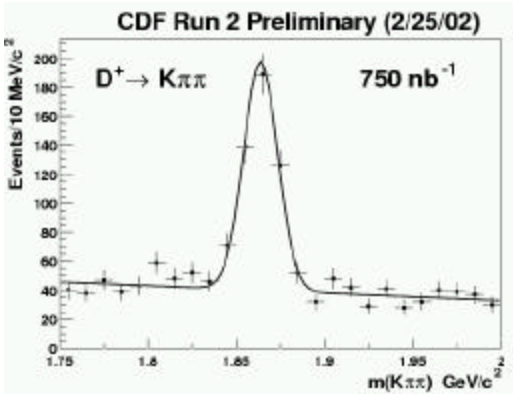
Heavy flavor physics in Run 2

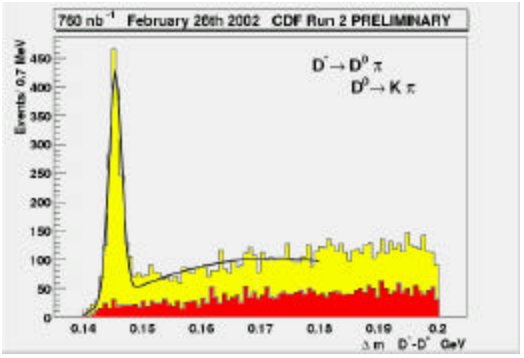
- Will be qualitatively better than the Run 1 program
  - 3d silicon vertex tracking (SVX)
  - Improved impact parameter resolution (L00 on beam pipe)
  - Particle ID via TOF and dE/dx (COT)
  - Online L2 secondary vertex trigger (SVT)
  - Higher rate trigger and DAQ
- Beauty physics will complement B factories [B_s, B_c, ? $_b$, rare decays] , CP violation studies (???)
- A new high sensitivity charm physics program

Charm Physics









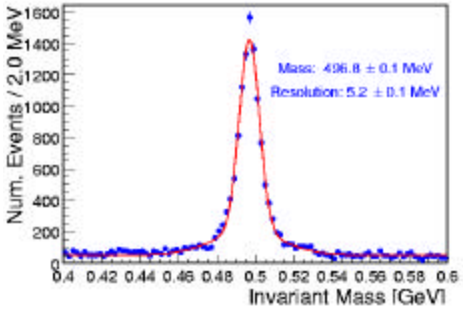
Very large charm signals. Opens up a new charm physics program. Important for beauty studies and SUSY searches.

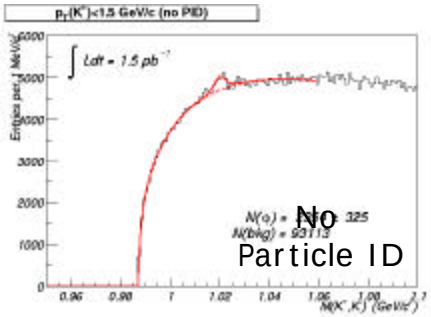
$D^o \rightarrow K^- ?^+$

50 pb^{-1}	2 fb^{-1}	E791	FOCUS	? (4S)/100 fb^{-1}
500K	20M	40K	120K	1M

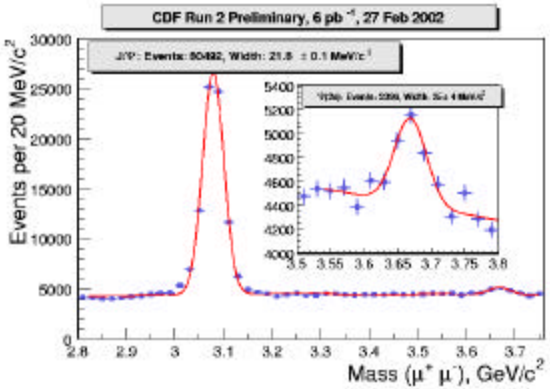
Assembling B Physics Ingredients …

$K_s \rightarrow \pi^+ \pi^-$

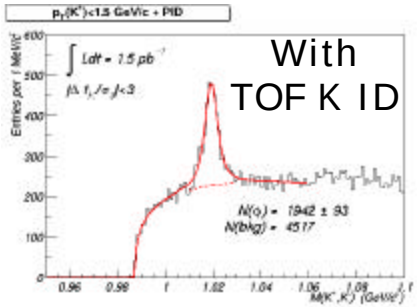




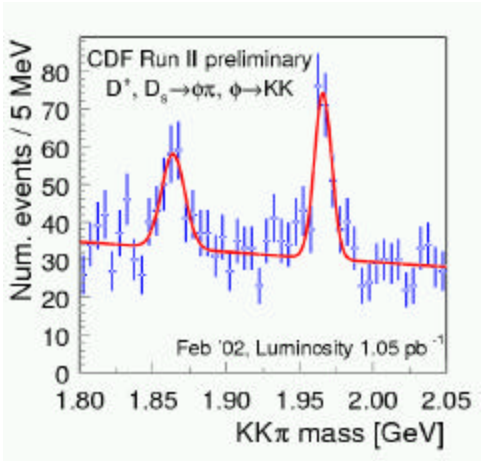
$J/\psi \rightarrow \mu^+ \mu^-$



$?? \rightarrow K^+ K^-$

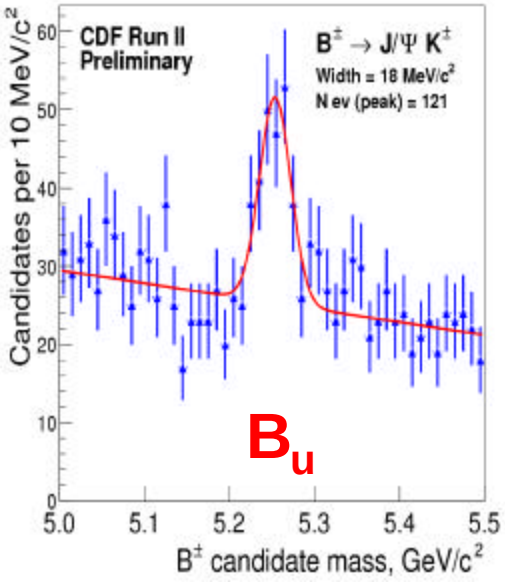


$D_s \rightarrow ? \ ?$

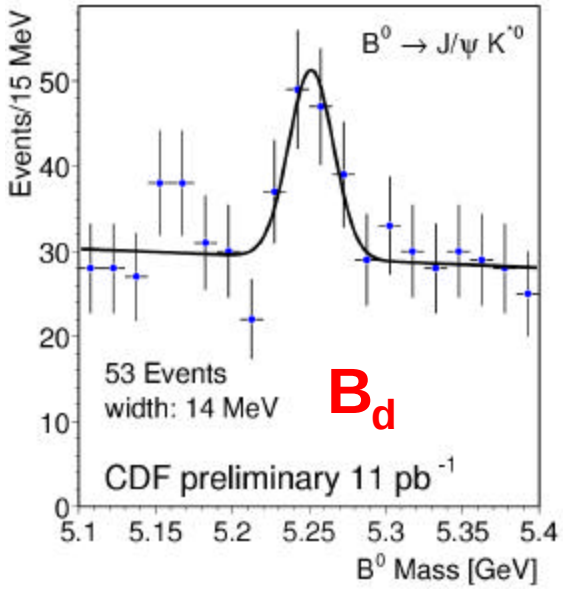


First B physics signals …

$B^{\pm} \rightarrow J/\psi\ K^{\pm}$



$B^{o} \rightarrow J/\psi\ K^{*o}$



CDF Run 2a Physics Program

- All physics groups deep into physics studies
  - Beauty and Charm
  - Electroweak
  - Top
  - QCD
  - New phenomena

- General plan:
  - First run 2 studies (mostly progress reports) summer-fall 2002
  - First analysis results (above run 1 statistics) winter 2003
  - New measurements from all physics groups summer 2003

  (B_s , B_c , ? $_b$, charm, W/Z+jets/photons, top, high E_t jets, eliminate or confirm Run 1 observations of anomalous events, ...)

Run 2b Upgrades

An Overview

Run 2b Upgrades

- Upgrades focused on preserving high Pt physics program (Higgs, SUSY, other heavy particles)
- Address specific limitations of detector at high integrated luminosities (> 5 fb^{-1}) and high instantaneous luminosities ($5x10^{32}$ $cm^{-2}s^{-1}$)
- Most components of CDF detector need no upgrades
- Upgrades will include:
  - Silicon vertex detector replacement (SVX + L00)
  - Central pre-radiator replacement
  - Addition of timing on electromagnetic calorimeters
  - Some trigger/DAQ upgrades

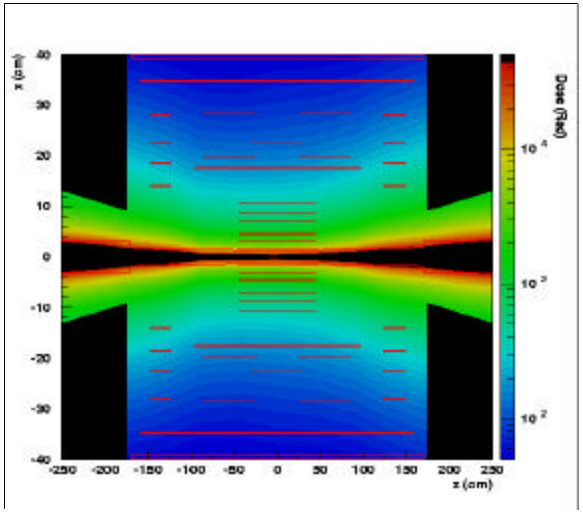
Silicon detector replacement

- This is the major part of the upgrade project
  - Determines the start and duration of the shutdown (~ 6 months)
  - Also the dominant part of the project cost
- The intermediate silicon tracker (ISL) will not be modified
- Replacement of SVX/L00 is required because of radiation damage

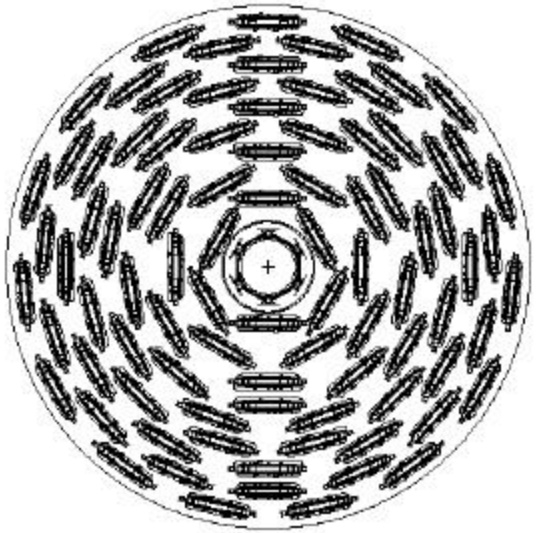
Estimates of radiation dose limits

Layer	Lifetime (fb $^{-1}$)
00	7.4
0	4.3
1	8.5
2	10.7
3	23
4	14

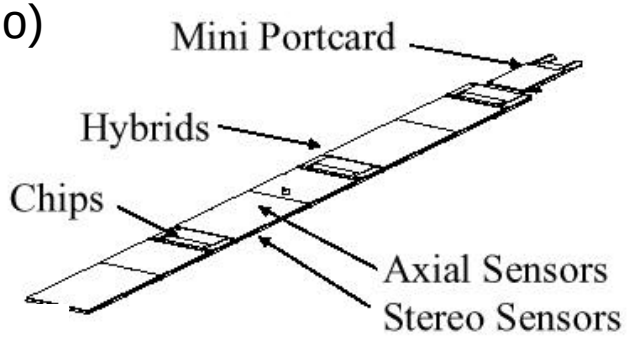
Measurements made from early Run2 operation confirm dose Estimates. radial dependence ~ $1/R^{?}$? = 1.6 1.7

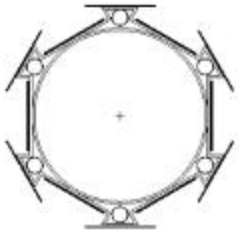


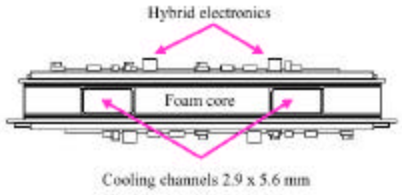
Silicon detector replacement



- Match or exceed performance of Run 2a SVX+L00
- Goal is a simple, robust design
  - Learn from experience with construction of SVX, SVX' ,SVXII and L00 detectors
  - Combine effort with D0 where possible
  - For layers 1-5
    - All sensors single sided silicon
    - 2 sensor types (axial and small angle stereo)
    - 1 hybrid with 4 chips (SVX4)
    - 1 stave core support structure
  - L0 is on beam pipe and replaces L00







Other Run 2b detector upgrades

- Replacement of central pre-shower radiator
  - Applications:
    - Improves electron and photon identification
    - Improves jet energy resolution (helps estimate EM fraction)
- Additional of timing to EM calorimeter towers
  - Application:
    - rejection of cosmic ray background from rare photon events.
- Extension of level 3 event builder with commercial ATM switch. Increases L3 input rate limit from 300 to 1000 Hz
  - Application:
    - Allows full acceptance of L2 high Pt accept rate expected to be ~ 600Hz for $L = 5 \times 10^{32}$.
- Additional trigger/DAQ (will profit from operational experience)
  - L1 track stereo information (reduces lepton trigger fakes)
  - New L2 CPU processors (more processing power
  - Possibly new TDC's (ability to buffer high hit rates).

Summary
CDF Status and Plans

- The Run 2a detector is collecting physics quality data and is ready for the higher Tevatron luminosity expected later this year.
- All physics groups are analyzing initial data, developing validation procedures, and tuning detector simulations at a level of detail far beyond that attained in Run 1.
- Plans for first Run 2 physics results are in place:
  - Progress reports in summer-fall 2002
  - First analysis results in winter 2003
  - New measurements from all physics groups in summer 2003
- Upgrades of the CDF detector for Run 2b are focused on high P_t physics searches. The exact scope will be defined in June after the Aspen PAC meeting.